International Geoscience and Remote Sensing Symposium

Development of Data Product Algorithms for the National Polar-orbiting Operational Environmental Satellite System (NPOESS)

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NPOESS: The Next Generation of Polar-Orbiting Satellites

- **Provide a national, operational, polar-orbiting remote sensing capability**

- **Converge DoD DMSP and NOAA POES satellite programs**

- **Incorporate new technologies from NASA**

- **Encourage International cooperation**

- **Base product requirements on user needs and Weather and other remote sensing mission heritage**

- **Goal of improving products and utility for the user**
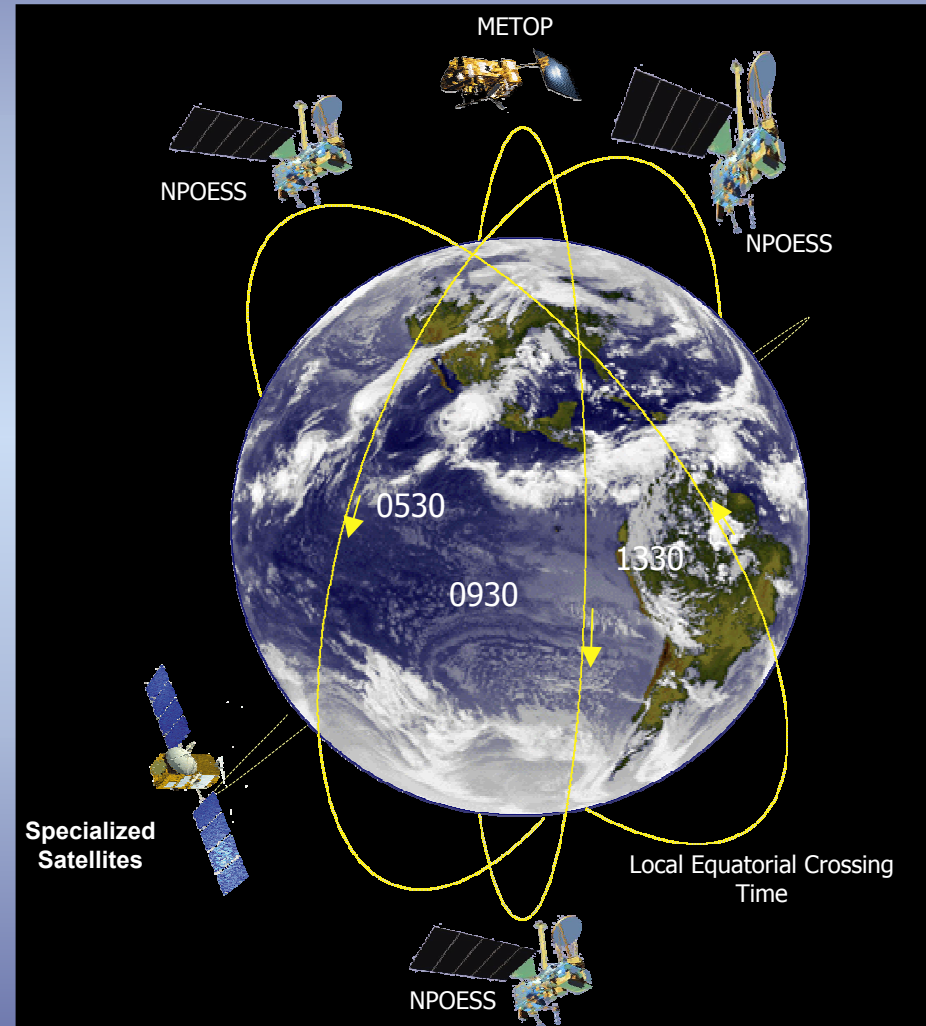
NPOESS Stored Mission Data (SMD) Will Produce 56 Environmental Data Records (EDRs)

Atm Vertical Temp Profile	Cloud Top Height	Ozone; Total Column/Profile
Atm Vertical Moisture Profile	Cloud Top Pressure	Precipitable Water
Imagery	Cloud Top Temperature	Precipitation Type/Rate
Sea Surface Temperature	Downward LW Radiance (Sfc)	Pressure (Surface/Profile)
Sea Surface Winds	Downward SW Radiance (Sfc)	Sea Ice Characterization
Soil Moisture	Electric Field	Sea Surface Height/Topo.
Active Fires	Electron Density Profile	Snow Cover/Depth
Aerosol Optical Thickness	Energetic Ions	Solar Irradiance
Aerosol Particle Size	Geomagnetic Field	Supra-Thermal-Auroral Part.
Aerosol Refractive Index	Ice Surface Temperature	Surface Type
Albedo (Surface)	In-situ Plasma Fluctuations	Surface Wind Stress
Auroral Boundary	In-situ Plasma Temperature	Suspended Matter
Auroral Energy Deposition	Ionospheric Scintillation	Total Water Content
Auroral Imagery	Medium Energy Charged Particles	Vegetation Index
Cloud Base Height	Land Surface Temperature	
Cloud Cover/Layers	Net Heat Flux	
Cloud Effective Particle Size	Net Solar Radiation (TOA)	
Cloud Ice Water Path	Neutral Density Profile	
Cloud Liquid Water	Ocean Color/Chlorophyll	
Cloud Optical Thickness	Ocean Wave Characteristics	
Cloud Particle Size/Distribution	Outgoing LW Radiation (TOA)	

⭐ EDRs with NPOESS Key Performance Parameters

NPP EDRs (26) in yellow font

VIIRS	22
CMIS	19
CrIS/ATMS	3
OMPS	1
SESS	13
GPSOS	2
ERBS	5
TSIS	1
ALT	3
APS	4

A Single EDR is Comprised of Multiple Attributes with Associated Requirements

Example: Sea Surface Temperature (SST)

" Sea Surface Temperature is defined as a highly precise measurement of the temperature of the surface layer (upper 1 meter) of ocean water."

"The accompanying requirements apply only under clear conditions (unless specified otherwise)."

Systems Capabilities	Thresholds	Objectives
a. Horizontal Cell Size		
Nadir, clear	1 km	0.25 km
Worst case, clear	1.3 km	
All Weather	40 km	20 km
b. Mapping Accuracy		
Nadir, clear	1 km	0.1 km
Worst case, clear	1.3 km	
All Weather	5 km	3 km
c. Measurement Range	-2° to 40° C	-2° to 40° C
d. Measurement Precision		
Clear	0.2° C	0.1° C
All Weather	0.3° C	0.1° C
e. Measurement Uncertainty		
Clear	0.5° C	0.1° C
All Weather	1.0° C	0.5° C
f. Refresh	6 hours	3 hours
g. Long-Term Stability	0.1° C	.05° C
h. Latency	90 minutes	15 minutes
i. Geographic Coverage	Global Ocean	Global Ocean

NPOESS Sensor Manifest and Locations Were Chosen to Meet Mission Data Product and Design Requirements
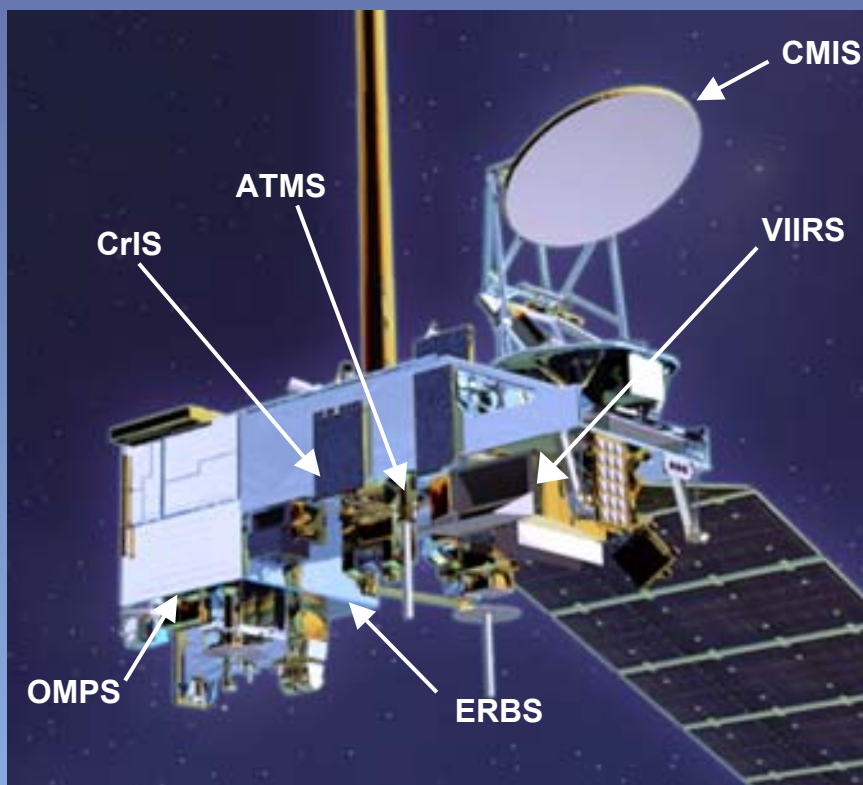
NPOESS 1330 Configuration

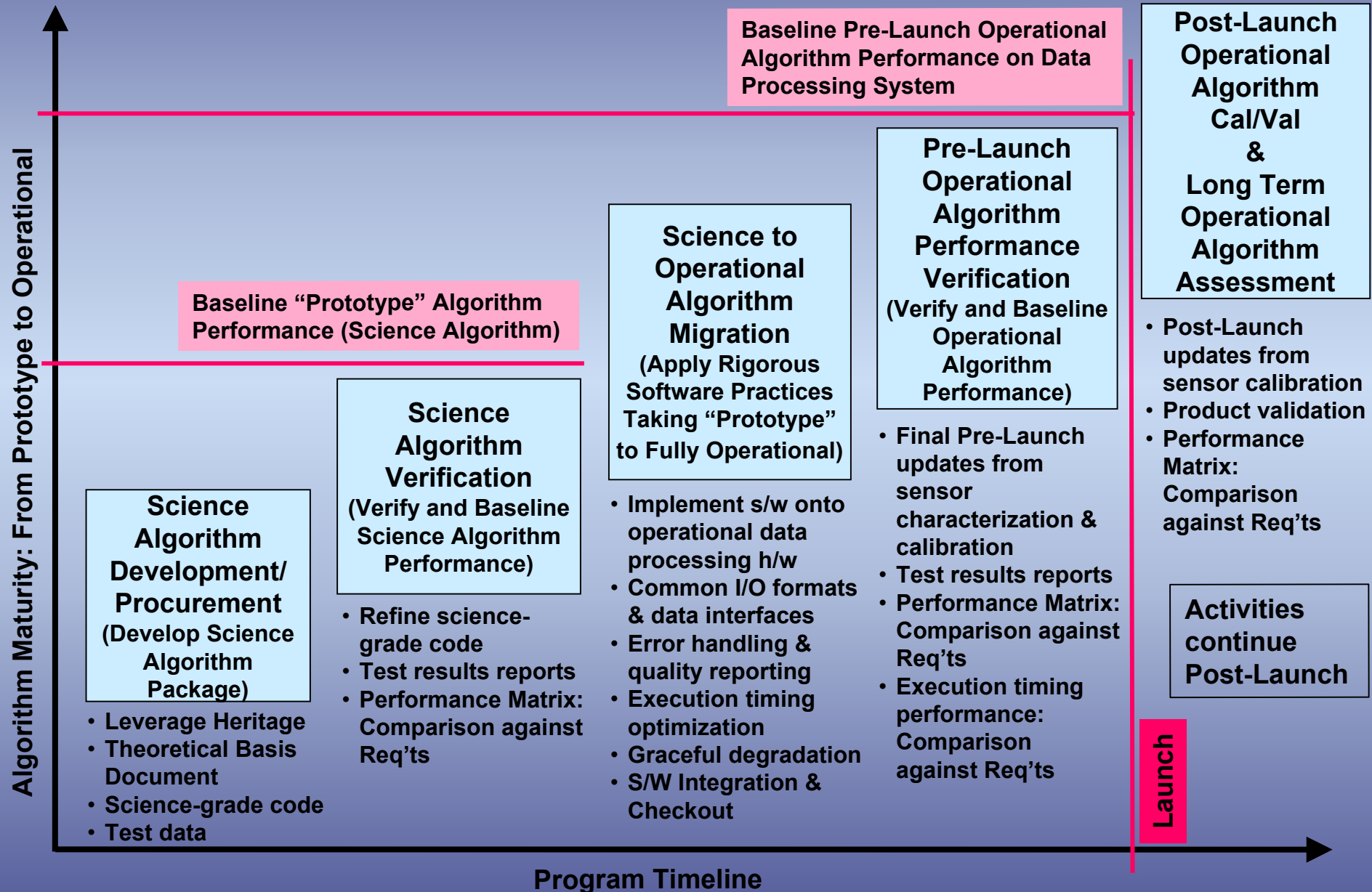|	1330	1730	2130	NPP
VIIRS	X	X	X	X
CMIS	X	X	X	
CrIS	X	X		X
ATMS	X	X		X
SESS	X			
GPSOS	X			
OMPS	X			X
ADCS	X	X		
SARSAT	X	X	X	
ERBS	X			
SS	X	X	X	
ALT		X		
TSIS		X		
APS			X	

NPOESS Data Products, Sensors, and Algorithms are a Progression from Heritage Systems

The algorithms being developed for NPOESS leverage, whenever feasible, heritage product retrieval algorithms and scientific approaches from DMSP, POES, EOS, and other systems

- **VIIRS (by Raytheon SBRS)**
  - ➢ MODIS (EOS), AVHRR (POES), OLS (DMSP)
- **CMIS (by Boeing)**
  - ➢ SSMI & SSMIS (DMSP), AMSR-E (EOS), TMI (TRMM)
- **CrIS (by ITT)**
  - ➢ AIRS (EOS), HIRS (POES), IASI (METOP)
- **ATMS (by Northrop Grumman ES)**
  - ➢ AMSU-A/B (POES & EOS), SSM/T&T2 (DMSP)
- **OMPS (by Ball ATC)**
  - ➢ TOVS (POES), TOMS, SBUV/2, OMI (EOS), GOME
- **SESS (Integrated by Ball ATC)**
  - ➢ SSM, SSI/ES, SSJ/5, SSULI, SSUSI, SEM,…
- **GPSOS (by Saab Ericsson)**
  - ➢ GRAS (METOP)
- **ERBS (by Northrop Grumman ST)**
  - ➢ CERES (EOS), ERBE (POES)
- **ALT (by Alcatel)**
  - ➢ Altimeter (TOPEX/Poseidon & Jason-1)
- **TSIS (by LASP at Univ of Co.)**
  - ➢ SORCE, ACRIM
- **APS (by Raytheon SBRS)**
  - ➢ MODIS (EOS), POLDER (ADEOS), MISR (EOS)

Operational Algorithm Development, Test, and Verification Work Progresses Via Key Activities

Algorithm Maturity: From Prototype to Operational (vertical axis)

Program Timeline (horizontal axis)

Baseline Pre-Launch Operational Algorithm Performance on Data Processing System

Post-Launch Operational Algorithm Cal/Val & Long Term Operational Algorithm Assessment

- Post-Launch updates from sensor calibration
- Product validation
- Performance Matrix: Comparison against Req'ts

Baseline "Prototype" Algorithm Performance (Science Algorithm)

Pre-Launch Operational Algorithm Performance Verification (Verify and Baseline Operational Algorithm Performance)

- Final Pre-Launch updates from sensor characterization & calibration
- Test results reports
- Performance Matrix: Comparison against Req'ts
- Execution timing performance: Comparison against Req'ts

Science to Operational Algorithm Migration (Apply Rigorous Software Practices Taking "Prototype" to Fully Operational)

- Implement s/w onto operational data processing h/w
- Common I/O formats & data interfaces
- Error handling & quality reporting
- Execution timing optimization
- Graceful degradation
- S/W Integration & Checkout

Science Algorithm Verification (Verify and Baseline Science Algorithm Performance)

- Refine science-grade code
- Test results reports
- Performance Matrix: Comparison against Req'ts

Science Algorithm Development/ Procurement (Develop Science Algorithm Package)

- Leverage Heritage
- Theoretical Basis Document
- Science-grade code
- Test data

Activities continue Post-Launch

Launch

Schedule for Algorithm Development, Test, and Verification Tasks is Integrated into NPP and NPOESS Program Schedule

2002
  A&O Contract Award

2003
  NPP Critical Design Review

2005
  NPOESS Preliminary Design Review

2006
  NPOESS Critical Design Review
  NPP Ground Readiness
  NPP Test Readiness Review
  NPP Launch
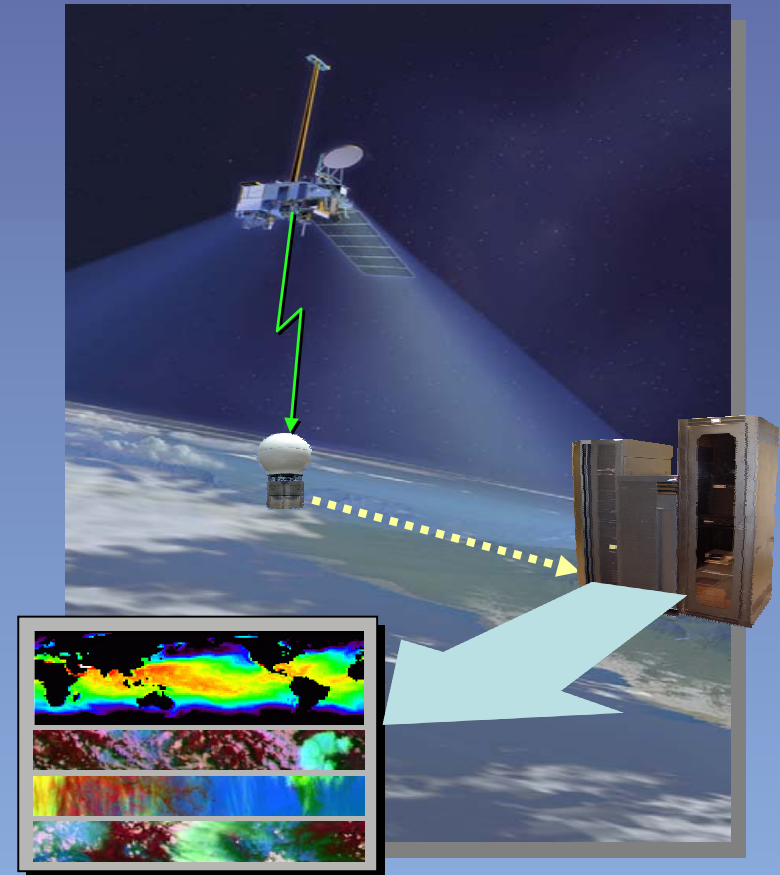
2007
  NPP On-Orbit Verification Review
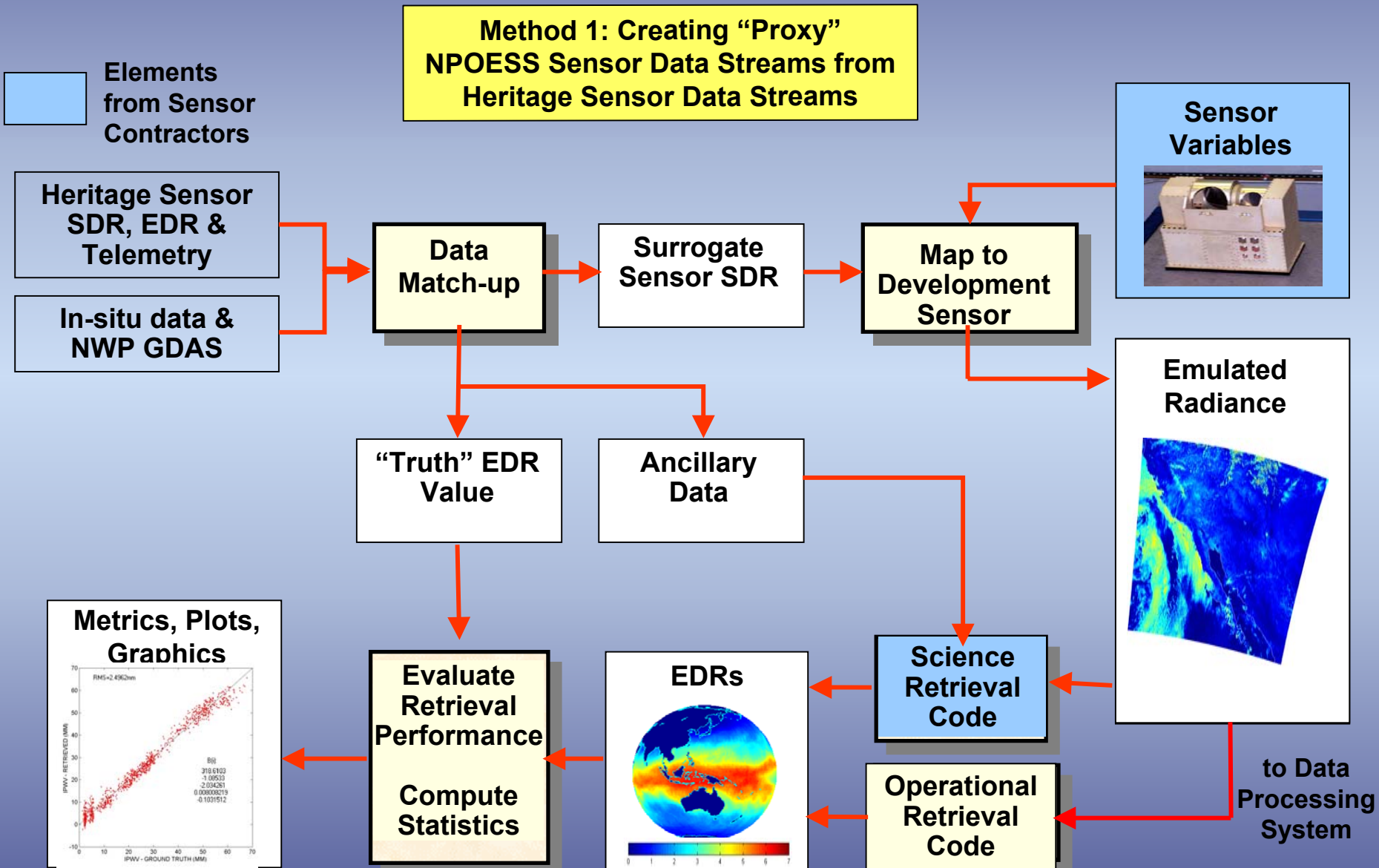
2009
  NPOESS Ground Readiness
  NPOESS C-1 Launch

2010
  NPOESS C-1 On-Orbit Verif. Review

Reliable and timely collection, delivery, and processing of quality environmental data

A Variety of Methods are Used Pre-Launch to Predict Product Performance Against Requirements

Method 1: Creating "Proxy" NPOESS Sensor Data Streams from Heritage Sensor Data Streams

Elements from Sensor Contractors

Heritage Sensor SDR, EDR & Telemetry

In-situ data & NWP GDAS

Data Match-up

Surrogate Sensor SDR

Map to Development Sensor

Sensor Variables

Emulated Radiance

"Truth" EDR Value

Ancillary Data

Metrics, Plots, Graphics

Evaluate Retrieval Performance

Compute Statistics

EDRs

Science Retrieval Code

Operational Retrieval Code

to Data Processing System

A Variety of Methods are Used Pre-Launch to Predict Product Performance Against Requirements

Method 2: Creating Simulated NPOESS Sensor Data Streams by Modeling Components and Physics

Elements from Sensor Contractors

Mission/Orbit Variables

Sensor Variables

Sensor/Space-craft Factors

Environmental Scenes:
Atmospheric Conditions

Background Conditions

Radiative Transfer Model

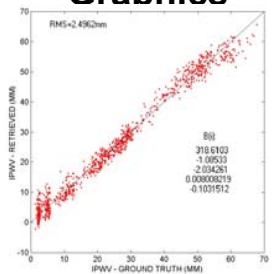Simulated Radiances at Aperture

Sensor Models

Spacecraft Convolution

Simulated Radiometric Temperatures
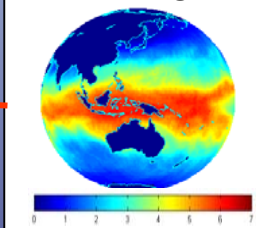
"Truth" EDR Value

Ancillary Data

Metrics, Plots, Graphics

Evaluate Retrieval Performance

Compute Statistics

EDRs

Science Retrieval Code

Operational Retrieval Code

to Data Processing System

The NPOESS Program Leverages the Knowledge Base in the Weather and Science Community

- **Government Teams**
  - **Operational Algorithm Teams (OATs)**
    - Advisors to the NPOESS Government Integrated Program Office (IPO)
    - Approx. 100 members and advisors drawn from across government and academia
    - OATs advise IPO on single and multi-sensor EDR integration into the ground system including algorithm performance
  - **NASA NPP Science Team**
    - Advisors to NASA NPP management at NASA Goddard
    - Specific science projects related to NPP; focus is on Climate applications and EOS to NPOESS continuity
- **NGST Contractor Teams**
  - **Subcontracts for specific algorithm development and improvement work**
    - Algorithm development companies
    - Experts from academia
    - Goal is to utilize available heritage experts and maintain continuity of effort
  - **NGST Science Advisory Team (SAT)**
    - Advisors to NGST Program Management
    - Small team of national recognized Weather/Remote Sensing experts led by Dr. J. Friday

Sound Science and Processes, Sound Operational Algorithms
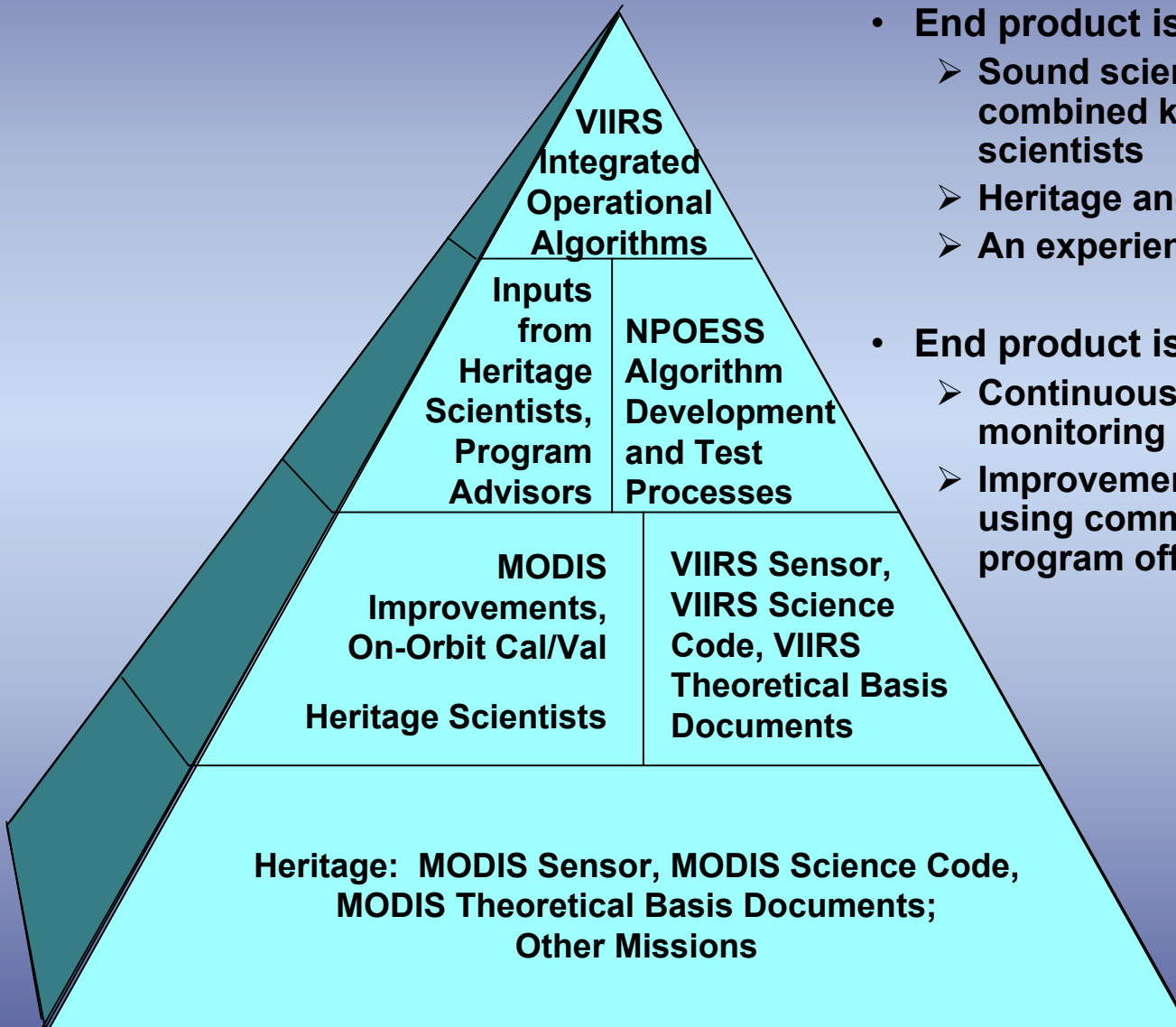
- **End product is based on**
  - ➤ Sound science that represents the combined knowledge of heritage scientists
  - ➤ Heritage and NPOESS sensors
  - ➤ An experienced aerospace industry base

- **End product is maintained by**
  - ➤ Continuous feedback via cal/val monitoring
  - ➤ Improvement at multiple levels by the using community as well as government program office and contractor

Pyramid levels (top to bottom):
- **VIIRS Integrated Operational Algorithms**
- **Inputs from Heritage Scientists, Program Advisors** | **NPOESS Algorithm Development and Test Processes**
- **MODIS Improvements, On-Orbit Cal/Val — Heritage Scientists** | **VIIRS Sensor, VIIRS Science Code, VIIRS Theoretical Basis Documents**
- **Heritage: MODIS Sensor, MODIS Science Code, MODIS Theoretical Basis Documents; Other Missions**